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NEOM Regional Baseline & Monitoring Program

**Noise and Vibration Monitoring Standards**

Amec Foster Wheeler Energy and Partners Engineering Company – February 2021

Report for

NEOM

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Document revisions

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Contents

[1. Introduction 4](#_Toc63709873)

[1.1 Preamble 4](#_Toc63709874)

[1.2 Project Background 4](#_Toc63709875)

[1.3 Purpose of the Standard 4](#_Toc63709876)

[1.4 Guide to the Standard 4](#_Toc63709877)

[1.5 Hierarchy of Requirements 5](#_Toc63709878)

[2. Reference Standards 6](#_Toc63709879)

[2.1 Best Practice and Guidelines 6](#_Toc63709880)

[2.2 Monitoring Objective 7](#_Toc63709881)

[2.3 Noise Level Guidelines 8](#_Toc63709882)

[3. Monitoring Equipment 10](#_Toc63709883)

[3.1 Noise 10](#_Toc63709884)

[3.2 Vibration 11](#_Toc63709885)

[4. Survey and Monitoring Methods 12](#_Toc63709886)

[4.1 Introduction 12](#_Toc63709887)

[4.2 Installation of Monitoring Equipment 12](#_Toc63709888)

[Location 12](#_Toc63709889)

[Measurements 13](#_Toc63709890)

[4.3 Quality Assurance/Quality Control 14](#_Toc63709891)

[Calibration 14](#_Toc63709892)

[5. Baseline Reporting 16](#_Toc63709893)

[5.1 Noise 16](#_Toc63709894)

[5.2 Vibration 17](#_Toc63709895)

Table 2.1 NEOM Noise Guidelines 8

Table 5.1 Acoustic Parameters and Maxima to Reprt 16

# Introduction

## Preamble

Amec Foster Wheeler Energy and Partners Engineering Company (hereafter referred to as “Wood”) is pleased to provide this technical methodology to NEOM. This technical methodology outlines our approach to conduct a regional baseline noise monitoring program, the scope of works to be performed including detailed information of the equipment to be used, references to international standards and best practice in the noise and vibration sector, minimum standards for equipment selection and deliverables.

Wood’s Environmental experiences in delivering noise and vibration assessment services date back over 20 years and spans the Middle East, Africa, Asia, the Americas and Europe. Wood operates under Amec Foster Wheeler Energy and Partners Engineering Company (AFWEPEC) based in Al-Khobar for delivering its environmental consulting services. The company is an approved EIA consultant registered with GAMEP and the Royal Commissions across Saudi Arabia.

## Project Background

Located in the northwest of Saudi Arabia on the Red Sea and Gulf of Aqaba coasts, NEOM spreads over an area of 26,500 km2 and encloses areas with a wide variety of activities and receptors.

## Purpose of the Standard

Noise and vibration surveys for NEOM will be carried out for different purposes and by different companies throughout the lifetime of the project. As part of the NEOM Regional Baseline & Monitoring Program, Wood have prepared this Standard, to ensure that baseline noise monitoring surveys for different NEOM developments are undertaken in a consistent manner and to a level that meets or exceeds international best practice. Vibration measurement standards are also referred to. Vibration standards are included to allow for consistency in future phases where vibration monitoring may be required near to sources such as railways, to determine whether the proposed use may be adversely affected by vibration. It is not generally intended to carry out baseline vibration measurements

The Standard represents a minimum acceptable approach to the monitoring. Noise and vibration specialists are expected to consider each project separately and design their survey based on the potential use of the site. Surveys may therefore need to extend the methodologies and go beyond the requirements of this document.

## Guide to the Standard

This document has been developed to describe in detail how the noise and vibration surveys shall be executed, including:

* **Reference Standards** to ensure the proposed approach is robust and based on internationally accepted guidance;
* **Monitoring Equipment** description (portable monitors), including details of installation procedures, use and maintenance;
* **Survey and Monitoring Methods** to provide details for survey execution; and
* **Baseline Reporting** structure describing how data collected through the survey shall be processed and presented to form the baseline for future Environmental and Social Impact Assessments.

## Hierarchy of Requirements

This Standard provides the overarching requirements for providing noise and vibration measurements that are controlled by the client.

In accordance with this Standard, contractors shall submit a Survey Execution Plan (SEP) that satisfies the minimum requirements. Thereafter, a survey monitoring report will be supplied to the client that summarises the survey undertaken and provides the data collected in the prescribed fashion.

# Reference Standards

This section details our approach and defines the reference standards on which the proposed methodology is based.

## Best Practice and Guidelines

The methodology for the noise monitoring program has been developed in accordance with guidance prescribed in the General Environmental Standard for Noise [[1]](#footnote-2).

The survey protocols and methodologies detailed within this Standard are tried and tested ways to evaluate noise levels to satisfy the stringent requirements for Environmental and Social Impact Assessment (ESIA) noise assessment in compliance with International and local standards.

The General Environmental Standard for Noise guidance relates specifically to:

1. community noise;
2. noise from industrial units in areas set aside primarily for industrial facilities;
3. noise from construction activities;
4. noise from vehicles (including motorised vessels and recreational craft); and
5. noise from equipment used outdoors.

The standard specifically excludes noise from public transportation, including highways, railways and noise from commercial and private aircraft, including helicopters, both in flight and operating on the ground, as well as military activities and call to prayer.

This Standard sets out the minimum requirements to undertake a survey in accordance with the compliance with the General Environmental Standard for Noise.

The sensitivity of receptors shall be considered in accordance with the General Environmental Standard for Noise

A **Quiet areas** – These areas are designated quiet areas as they hold value in terms of them being places of worship, important tourist attractions, recreational park land and those areas surrounding hospitals, schools and noise sensitive natural habitats.

B **Sensitive** – Areas designated in this category will typically be dominated by residential properties (including hostels and hotels) and may range from sparse population densities to suburban districts of cities.

C **Mixed** – This designation applies to mixed areas, often within cities where there is a mix of residential and commercial activities. This designation will also apply to retail and financial districts.

D **Non-sensitive** – The final classification of district is a predominantly industrial area where there are few residential properties and commercial premises. This classification also applies to industrial cities and land that is generally unpopulated.

In line with the specifics of the NEOM project, the monitoring program will be based on the following principles:

* Monitoring shall be carried out in the area of proposed or existing industrial facilities, commercial areas, educational campuses, residential areas, and areas proposed for leisure pursuits
* Noise monitoring programs shall be designed by trained specialists. The monitoring shall be carried out by engineers with appropriate training;
* Typical monitoring periods shall be a minimum 15 minutes and sufficient for statistical analysis. Monitoring should be carried out over differing time periods and durations in order to determine diurnal and seasonal patterns. The nature of the programme shall be at the technical specialists’ discretion and be relevant to the proposed use of the data.
* Sound level meters shall be capable of logging data continuously over the selected time period;
* Monitoring will cover differing time periods, including weekday and weekend days and nights;
* The type of acoustic indices recorded will be defined within this Standard;
* Monitors shall be located approximately 1.5 m above the ground and no closer than 3 m to any reflecting surface (e.g. wall); and
* Sampling and analysis methods, including quality assurance and quality check (QA/QC) shall be conducted by, or under, the supervision of trained individuals.

The proposed approach considers that sampling will be undertaken by trained professionals and overseen a team lead recognized by the Institute of Acoustics (IoA) to undertake noise and vibration assessments.

## Monitoring Objective

The objective of the noise monitoring is to establish baseline background and ambient noise levels at locations around the NEOM area.

As a minimum the study will provide sufficient information to characterize the acoustic conditions where future developments will be located.

The primary purpose of the monitoring Standard is to ensure comparability of data across the NEOM area that will be used to achieve the following objectives:

* Measure representative noise levels across the NEOM project area;
* Develop monitoring criteria for spot measurements i.e. determining suitable monitoring times and frequencies;
* Measure existing background levels;
* Support the development of appropriate management strategies in the NEOM area; and
* For future purposes this will assist in ensuring measurements are reliable and comparable across the NEOM area.

## Monitoring Standards

### Noise

Noise measurements shall be undertaken in accordance with British Standard 7445 Part 1[[2]](#footnote-3)

### Vibration

Vibration standards are being reviewed to determine suitable measurement standards to apply to NEOM. This section will be completed in the next update of this Standard and in any case before any vibration monitoring will be required.

## Noise Level Guidelines

Table 2.1 below reproduces and adds to core information from Tables 2 and 4 of the General Environmental Standard for Noise guidance. The guidance on levels to be achieved informs the metrics required for baseline noise surveys.

The General Environmental Standard for Noise guidance is summarized in Table ‎2.1 .

Table ‎2.1 NEOM Noise Guidelines

| Receptor | Index | Limit or target | Daytime  07:00 – 19:00 | Evening  19:00 – 23:00 | Night time  23:00 - 07:00 |
| --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |
| A Community Noise - Permitted free-field external noise limits for community noise, measured at any noise sensitive property within the appropriate area designation (Notes 1 and 2) | | | | | |
| A | LAeq, T | Limit | 50 dB | 45 dB | 40 dB |
| B | LAeq, T | Limit | 55 dB | 50 dB | 45 dB |
| C | LAeq, T | Limit | 60 dB | 55 dB | 50 dB |
| D | LAeq, T | Limit | N/A | N/A | N/A |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| B Construction Noise - General construction maximum permissible facade noise limits (at 5m from façade) | | | | | |
| A | LAeq, T | Limit | 75 dB | 65 dB | 45 dB |
| B | LAeq, T | Limit | 75 dB | 65 dB | 45 dB |
| C | LAeq, T | Limit | 75 dB | 65 dB | 45 dB |
| D | LAeq, T | Limit | 80 dB | 80 dB | 80 dB |

Note 1) For a single noise emitting premises the noise levels in Table 2.1A shall pertain. In instances where there are two separate noise emitting premises the limits in Table 2.1A shall be reduced by 3dB (A) for each individual premises. For areas where there are more than two noise emitting premises the limits applied to each individual premises in Table 2.1A shall be reduced by 5 dB(A).

Note 2) Further to the permitted noise limits specified within Table 2.1A and in order to achieve a reasonable standard within habitable rooms at night, individual noise events during the night-time period (measured with the fast time-weighting) should not exceed 60dB LAmax at the nearest noise sensitive property (Receptor Categories A, B and C only).

# Monitoring Equipment

## Noise

Noise Monitoring equipment used on the NEOM project shall conform to the following minimum standards:

* Any sound level meter used to undertake measurements shall comply with the requirements for a ’class 2’ instrument or better as defined in IEC 61672-1[[3]](#footnote-4) and IEC 61672-2[[4]](#footnote-5);
* Any calibrator shall comply with the requirements for a class 2 specification or better as defined in IEC 60942[[5]](#footnote-6);
* A windshield that is effective for the nature of the measurement being undertaken, shall be fitted to microphones;
* The measurement system shall measure Sound Pressure Level over the frequency range 20 Hz to 20 kHz, and be capable of applying the “A” frequency weighting and the “Fast” time weighting;
* The measurement system shall be capable of recording a .wav file of 2 minutes per hour where the surveyor determines that the acoustic environment may possess characteristics that may need further investigation off-site;
* Continuous measurements shall log the following weighted parameters for every 15 minute interval: LAeq,15min, LAFmax, LAFmin, LA10,5min, LA90,5min;
* Continuous measurements shall log the un-weighted (or Z-weighted) Lpeq,5min in octave bands between 31.5 Hz and 8 kHz every 5 minute interval;
* The measurement system shall be equipped with a memory device in order to store the data locally. The power supply and storage size shall be sufficient for the type and duration of the measurements; and
* Be capable of synchronisation to an external clock, for the following reasons:
* Contemporaneous observations of precipitation and wind speed and direction shall be recorded. For long-term monitoring, this will require correlation to a nearby met station (less than 20km away); and
* For a measurement site or for any receptor, the clocks on all sound level meters and meteorological stations shall all be synchronised to a global positioning system / radio-clock to ensure consistency of timings and to allow for correlations between measurement locations. The precision of the synchronization system will depend on the desired accuracy of the measurement undertaken.

## Vibration

Placeholder – Vibration section is currently being authored. No vibration monitoring will be required in the 1st year of the project, by which time this document will have been updated to include minimum standards (update expected by April 2021)

# Survey and Monitoring Methods

## Introduction

The Contractor shall submit a survey plan to NEOM to seek comments and acceptance prior to commencing the noise and / or vibration survey.

Noise surveys shall be expected to be undertaken in accordance with BS 7445-12.

For the remainder of this Standard, the term ‘noise’ should be inferred to mean noise and/ or vibration, unless otherwise stated.

## Installation of Monitoring Equipment

### Location

The Contractor shall submit proposed locations for noise monitoring in ESRI shapefile format, projected in WGS84 lat/long. to seek comments and acceptance prior to commencing the survey. The final survey plan will include the agreed locations and further information as set out below.

All monitoring equipment shall be installed at the agreed locations in a safe manner without putting the installer or the general public at risk of harm. In the event that the situation on the ground means that an alternative (proxy) location has to be identified, and the exact location (including coordinates) of the proxy and the reasons why it was used, shall be included in the survey report.

All persons installing, operating and maintaining the instruments shall be appropriately qualified and suitably experienced. Staff training records shall be kept.

All monitoring equipment shall be connected to an electricity supply (or an alternative reliable energy source) for the duration of their use.

The operation, calibration and servicing of monitoring equipment shall be undertaken in accordance with the manufacturer’s guidance where available, or best practice where no guidance is given

For all monitoring locations a suitable substitute shall be provided during:

* Service periods;
* Periods when equipment is removed for full certification and calibration; and
* Equipment malfunctions.

The calibration, ad-hoc and routine maintenance records, including details and actions taken to resolve equipment failures shall be recorded and retained for inspection. These records shall also contain any supporting information to explain any data gaps caused through fault resolution.

Where long term monitoring is carried out, the Contractor should consider whether the data should be transmitted from the measurement instrument to a web-based software system which collects, manages and displays the results on a secure site which supports multiple users. The software should retain a searchable database of results, allow downloading of results which can be opened in a spreadsheet, and have the capability to prepare automated reports.

Where a remote transmission system is used, data should be checked on a weekly basis by appropriately qualified and suitably experienced personnel to identify any potential fault with the equipment (either mechanical or vandalism).

Where issues with the equipment occur, personnel shall investigate the cause of any faults and repair if applicable. A log book detailing all actions taken along with any loss of data recording shall be maintained and made available to NEOM upon request.

Any failure of monitoring equipment (either by repair or replacement) shall be resolved within 72 hours of notification of failure.

Instruments shall be physically inspected on a regular basis (at least once per month) to check for any damage.

### Measurements

Measurement shall be reported as free-field levels.

Outdoor measurements shall be made at a height of 1.2 to 1.5m above ground level (to approximate a ground floor level) or at a height of 4m (to approximate a first floor level) unless there is a specific reason to use an alternative height (which should be justified), and under similar conditions, e.g. similar influence of reflections and measurement height above the ground.

Where practicable in order to minimise the influence of reflections, measurements shall be made at least 3.5m from a reflecting surface other than the ground or a flat roof.

Where it is necessary to undertake measurements above ground floor level, measurements shall be taken 1m from the façade on the relevant floor of the building if it is not practical to make measurements at least 3.5m from the façade at this elevation.

When measurements are made at 1m from a façade a correction of -3 dB shall be applied (except for railway sources where alternative corrections may be applied with client’s agreement to the data in order to provide free-field sound level values from these measurements). The notes shall identify the reason for any adjustment, and its value.

All noise measurement instruments shall be capable of being easily retracted or accessed for calibration.

Precautions shall be taken to avoid potential sources of interference, including:

* wind passing over the diaphragm of the microphone – to be suitable for the purposes for which the noise levels are being monitored;
* rain falling on the microphone windshield or nearby surfaces;
* temperature; and
* electrical and electromagnetic interference caused by nearby power cable or radio transmitters.

Survey personnel shall document the following subjective information as required:

* notes of audible sound sources;
* notes of weather conditions,
* description of the character and quality of the sound environment;
* identification of areas of specific acoustic interest or tranquillity;
* comments regarding likely future changes in noise level (e.g. due to known future developments, etc.); and
* identification of any sound sensitive receptors which were not previously known.

Survey personnel shall document the following objective information where possible:

* measurement position (GPS coordinates in the form latitude, longitude (WGS84) [reported to 6 decimal places]);
* photographs from source to microphone and from microphone to source,
* uncompressed (.wav) audio recordings,
* date and time of measurements;
* instrumentation used and serial numbers;
* instrument calibration levels; and
* measurements of wind speed.

Hard copies of field forms shall be compiled for each survey as backup in case of technical issues with tablets.

If the equipment is to be decommissioned, it shall be removed in a safe manner without putting the installer or the general public at risk of harm.

All persons removing the instruments shall be trained in their shut-down procedure.

The working area shall be cleared and shall be made good.

Should the monitoring equipment be left in situ, the arrangements for this shall be agreed with the land owner or manager as appropriate.

## Quality Assurance/Quality Control

Site visits, instrument calibrations and program audits are all important elements of an effective QA/QC system. Requirements are somewhat dependent on the sampling methods employed and resources available, but each element will be adhered to as part of the QA/QC procedure.

### Calibration

The complete measurement system shall have traceable calibration to either National or International Standards by a laboratory recognised by the Saudi Accreditation Committee (SAC) approved (or equivalent e.g. UKAS) test laboratory.

The interval between the verification of the complete measurement system shall not exceed two years.

The interval between the verification of acoustic calibrators shall not exceed one year.

At the beginning and end of every measurement session, the measurement equipment shall be calibrated at one or more frequencies in accordance with the manufacturer’s instructions, by means of a sound calibrator fitted over the microphone.

Interim calibrations, either internal calibrations carried out remotely, or by use of an acoustic calibrator shall be made. These calibrations shall be carried out at intervals as recommended by the manufacturer, but acoustic calibrator checks shall be carried out at intervals of not less than 3 months.

Interim calibrations shall be made and recorded to verify results if at any time during a measurement period it appears that the equipment is reading incorrectly. If the difference between the initial and interim calibrations is greater than 0.5 dB:

* The instrument shall be adjusted to correct the calibration error; and
* Results shall be highlighted as being associated with abnormal calibration of the monitoring equipment and the size of the measurement error noted such that the potential uncertainties in the results are highlighted.

Where the difference between the initial calibration value, any subsequent interim calibration check, and a final calibration check on completion of measurements is 1.0 dB or more, the measurement chain shall be thoroughly investigated to determine the source of the drift. If a fault in the noise measuring system is identified, then the data shall be marked as highly uncertain, treated with extreme caution and not used for important decision making. Unless there is a clear reason for the calibration drift that does not indicate a fault with the system, the noise measuring system shall be temporarily replaced and returned to the manufacturer (or equivalently competent laboratory) for test and repair.

# Baseline Reporting

Regular monthly progress reports will be issued to NEOM including basic analysis. On completion of the baseline monitoring, a baseline report shall be submitted setting out all relevant information regarding the noise surveys, and summarized findings including all parameters listed in section.

## Noise

The purpose of baseline noise monitoring is to document the ambient noise conditions prior to the start of construction works and thus provide information to inform masterplanning, environmental assessment, and design. It is therefore important to be able to distinguish between daytime and night time data and to confirm that data that has been affected by high winds, rain, etc., has been excluded from the final baseline noise assessment.

Raw data from each monitoring location shall be issued to NEOM on request. All raw data shall be subjected to a verification check prior to transmission. The date of last calibration and any drift noted shall be provided, along with information specifically listed for raw data below.

A basic monthly report shall be issued to NEOM to confirm the daytime and night time weekday and weekend noise levels at each monitoring location to ensure that the project has up to date data. Data shall be presented in spreadsheet format.

Monthly reports shall be quality assured by qualified and suitably experienced personnel to confirm that the data is valid and suitable for further use prior to issue to NEOM.

Any raw data which has been collected under unsuitable weather conditions (for example during rainfall or wind speeds exceeding 5m/s (unless gathered for windfarm baseline)), missing data or unusually high/low levels shall be highlighted. The data shall be submitted along with a covering note which should summarise any concerns, explain what data (if any) has been highlighted and provide a reason for this (or a description of the investigative work to be undertaken before the monthly report is prepared), and record any loss of data over the period.

The data highlighted above will be addressed in full in the monthly report.

A template for the monthly report shall be prepared and populated and includes as a minimum:

* Description of monitoring location and any activities occurring nearby/within the site that could be sources of noise or vibration;
* Description of noise or vibration monitoring equipment including serial numbers and dates of last calibration;
* Dates and results of field calibration checks within the reporting period;
* Commentary on weather conditions and any data excluded due to unsuitable weather conditions and/or any uncertainty in the results due to weather related interference;
* Summary of measured noise or vibration levels over the reporting period including the typical hourly level for weekday daytime, Friday, Saturday, and night times;
* Provide data for the periods as shown in Table 5.1 (below) in graphical form; and
* Report on the typical hourly level (mode average) for weekday, Friday, Saturday, evenings and night time.

For the final report, the information in **Error! Reference source not found.** shall be reported.

Table ‎5.1: Acoustic Parameters and Maxima to Report

|  |  |  |  |
| --- | --- | --- | --- |
| Graph | Day | Time Period | Data to Report |
| Graph 1 – Weekdays | Week day | 0700 – 1900 hours | LAeq, 1 hour, LAFmax, 1hour, LA10, 1hour, LA90, 1hour |
| Graph 2 – Friday | Friday | 0700 – 1900 hours | LAeq, 1 hour, LAFmax, 1hour, LA10, 1hour, LA90, 1hour |
| Graph 3 – Saturdays | Saturday | 0700 – 1900 hours | LAeq, 1 hour, LAFmax, 1hour, LA10, 1hour, LA90, 1hour |
| Graph 4 – Evenings | All days, evening | 1900 – 2300 hours | LAeq, 1 hour, LAFmax, 1hour, LA10, 1hour, LA90, 1hour |
| Graph 5 – Night time | All days, night | 2300 – 0700 hours | LAeq, 1 hour, LAFmax, 1hour, LA10, 1hour, LA90, 1hour |

## Vibration

To be added in next update



1. The General Environmental Standard for Noise, Presidency of Metrology and Environment, 01/05/1433H (24/03/2012 CE) [↑](#footnote-ref-2)
2. British Standard 7445-1 Description and measurement of environmental noise. Guide to quantities and procedures, BSI, 2001. Available at <https://shop.bsigroup.com/ProductDetail?pid=000000000030098820> [↑](#footnote-ref-3)
3. International Electrotechnical Commission (2013). IEC 61672-1:2013, Electroacoustics - Sound level meters - Part 1: Specification. Available at: <https://webstore.iec.ch/publication/5708> [↑](#footnote-ref-4)
4. International Electrotechnical Commission (2013). IEC 61672-2:2013, Electroacoustics - Sound level meters - Part 2: Pattern evaluation tests. Available at: <https://webstore.iec.ch/publication/5709> [↑](#footnote-ref-5)
5. International Electrotechnical Commission (2017). IEC 60942:2017, Electroacoustics - Electroacoustics - Sound calibrators. Available at: <https://webstore.iec.ch/publication/30045> [↑](#footnote-ref-6)